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PERFORMANCE EVALUATION OF MULTICAST ROUTING PROTOCOLS IN MOBILE AD HOC NETWORKS

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ABSTRACT

A Mobile Ad hoc Network (MANET) is a wireless network with mobile terminals that are able to form a temporary network without wired infrastructure and centralized administration. Due to its open architecture and mobility features, MANET is in demand by researchers and industries for various application areas. Multicasting is mainly used for group-oriented computing, which can reduce communication costs, processing overhead and delivery delay. Many application such as disaster management, emergency relief, distributed database and multimedia applications like video conferencing, video-on-demand services require multicast communication. Various multicast routing protocols are available to support such multicast communications. MANET's Inherent characteristic such as unpredictable node density, node mobility and dynamic communication environment generates challenges to provide an efficient multicast routing protocol. A tree based multicast protocol MAODV and mesh based multicast protocol ODMRP are compared for performance metrics with different network situations. Performance evaluation is done for packet delivery ratio, average end-to-end delay, routing overhead and throughput with CBR and multimedia traffic for varying node density, number of senders, multicast group size and node mobility.

KEYWORDS: Mobile Ad hoc Network (MANET), Multicast Routing Protocols, MAODV, ODMRP

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I. INTRODUCTION

MANETs are self-organizing networks established among mobile nodes equipped with communication facilities without centralize administration and fixed infrastructure. Mobile nodes are network nodes so that each node can act as the source of data, destination for data and a network router. Routing protocol plays vital role in node's multi hop communication in dynamic environment of MANET. MANETs have some characteristics such as absence of central administration, varying communication environment with unpredictable node density and mobility creates problems in routing. Absence of central administration, fast changing network topology and varying communication conditions pose a great challenge for routing protocols being used in MANETs. Many application areas such as disaster relief management, military networks, distributed database and online gaming, video conferencing like multimedia applications requires multicast communication among nodes. Various multicast routing protocols are available to support multicast communication where sender send packets to many receivers with unique address.

The objective of a multicast routing protocol for MANET is to support the dissemination of information from a sender to all the receivers of a multicast group while trying to use the available bandwidth efficiently in the presence of frequent topology changes [1]. Multicast routing protocols are mainly defined as Topology Based

Multicast Routing Protocol, Initialization Based Multicast Routing Protocol and Maintenance-Mechanism Based Multicast Routing Protocol. Topology based multicast routing protocols can be further divided as tree-based multicast routing, mesh-based multicast routing and hybrid multicast routing. This classification is on the basis of route finding mechanisms and routing architectures of the protocol. In this paper performance evaluation is done for tree based protocol MAODV [2] with mesh based protocol ODMRP [5]. The performance of protocol is in terms of Packet Delivery Ratio, Average End-to-End delay, Routing overhead and Throughput for constant bit rate (CBR) traffic and Multimedia traffic. The performance metrics measurements are with respect to node density, number of senders, multicast group size and node mobility.

The paper is organized as follows. Section II describes multicast routing protocol MAODV and ODMRP. Section III describes related work on performance evaluation of MAODV and ODMRP in MANET. Section IV contains details about network simulation model. Section V discussed result evaluation and section VI concludes the paper.

II. MANET MULTICAST PROTOCOLS

A. MAODV[2][3]

Multicast Ad hoc On-Demand Distance Vector (MAODV) [2][3] routing protocol is a shared-tree based protocol which is a multicast extension of the AODV [4] protocol. It enables dynamic, multihop routing between participating mobile nodes who want to join or take part in a multicast group within an ad hoc network. MAODV enables mobile nodes to establish a tree connecting multicast group members.[3] MAODV uses group sequence number and unique address to identify multicast group. Each multicast group has its own group sequence number which is initialized and then updated periodically by the multicast group leader. This sequence number confirms that the routes to multicast groups are always the most current ones available. All the group members and forwarding nodes (part of tree but not group member) compose the tree structure. Group leader is the first group member who constructs the tree. It maintains tree by periodically broadcast Group-Hello (GRPH) message. Route request (RREQ) and route reply (RREP) messages are used by each node as route discovery mechanism to build multicast route. Nodes can join the group by sending a unicast route request (RREQ) message if group leader is known otherwise broadcast route request (RREQ) message. Members of the multicast group replies its hop count (distance) from group leader and group sequence number with RREP packet. The node wishing to join sends multicast activation (MACT) message to the nearest member with an upgraded group sequence number. When intermediate node receives MACT it becomes the member of the tree. Tree pruning is done when a node leaves the multicast group by sending prune message upstream. The most downstream node repairs the breakage in case of link breaks or failure.

B. ODMRP [5][6]

On Demand Multicast Routing Protocol (ODMRP)[5][6] is a mesh based multicast routing protocol designed for mobile ad hoc networks. It uses a forwarding group (mesh of nodes) which forward the multicast packets via flooding in mesh. The mesh structure provides rich connectivity, robustness, and supplying path redundancy [6].In ODMRP, group membership and multicast routes are established and updated by the source on demand [7]. It requiring periodic join query (JREQ) messages only when sources have data packet to send. Each source in the multicast group floods a join query (JREQ) control packet periodically to form a mesh during mesh establishment phase. This packet is periodically broadcast in the network to find updated route and membership information. Each intermediate node that receives RREQ packet store information in “message cache”. It also update its “routing table” with upstream node identity before broadcasting the packet. The destination node (multicast receivers) respond to the request by sending a Join Reply (JREP) through the

shortest reverse path. The Join Reply (JREP) packet consists of the Source Id and the Next Node ID. If intermediate node is on path to the source it sets FG FLAG (Forwarding Group Flag) and become a part of forwarding group. These nodes are responsible for forwarding (broadcast) multicast packet of group. This way, the Reply is propagated by each forward group member until it reaches the multicast source via the selected path [6]. ODMRP uses a soft state approach to maintain the mesh through employing a mesh refreshment mechanism in which the source periodically floods the RREQ control packet. ODMRP have also capability to work as unicast in network. Mesh maintenance approach is soft state which provides robustness but with high control overhead.

III. RELATED WORK ON PERFORMANCE EVALUATION

Following are some of the research work on performance evaluation of MAODV and ODMRP in MANETs.

Aparna K. [7] presents a comparative performance of ODMRP, AMRIS and MAODV focusing on the effect of changes such as the increasing number of receivers, no. of sources and no. of nodes. ODMRP is more effective than MAODV in PDR as the number of senders incremented from 0-20, after that all protocol performance is not good. With respect to increase in the group member size MAODV is doing well than ODMRP in terms of PDR.

Alexandros V. et al. [8] evaluates MAODV and ODMRP performance with respect to the network traffic, the node speed, as well as the area and the antenna range for different simulation scenarios. MAODV performs better for high traffic. ODMRP performs better for large areas and high node speeds and poorer for small antenna ranges.

Mustafa Ali et al. [9] evaluated performance of MAODV protocol. MAODV achieved better PDR for the smaller area but if the area size increases PDR is deceases while achieves best time delay and latency.

Manoharan R. et al. [10] in 2010 evaluated impact of mobility on the performance of multicast routing protocols in MANET. Performance of protocol was done with Manhattan mobility model, Random Way Point Mobility model and Reference Point Group Mobility model. MAODV performs better for PDR compared to ODMRP and ADMR. The throughput of ODMRP protocol depends purely on the mobility model and not much based on the speed of mobile nodes. ADMR is able to maintain high throughput for all mobility models even the speed increases. ADMR has minimum routing overhead compared to MAODV protocol for all the mobility models.

Madhanmohan P. et al. [11] performed an experiments to explore the performance nature of MAODV and ODMRP with respect to a number of parameters such as no. of senders, node mobility and multicast group size. ODMRP is better than MAODV in PDR but it has higher overhead. ODMRP has not have good scalability with respect to number of sender and group size increases.

Vijayaragavan S. et. al. [12] analyzed performance of Group learning module of VCR using MAODV and ODMRP for parameters such as network traffic, the node speed and the network area. VCR has been designed to support both text based discussion and transfer of study materials in a form of compound file which contains multimedia data. For small areas, MAODV achieves better PDR while ODMRP achieves better latency. For large areas, ODMRP achieves better PDR while MAODV achieves better latency. For high traffic ODMRP is slightly better than MAODV. For different node speeds, both protocols perform well with ODMRP performing better as the speed increases. Based on this analysis, MAODV is found to provide better performance in VCR environment.

Thomas Kunz and Ed Cheng [13] evaluated performance of MAODV and ODMRP. Results shows that in many scenarios ODMRP achieves a higher PDR, but results in much higher overheads. ODMRP in particular dose not scale well for PDR as increases number of senders and multicast group size.

Nair K. et al. [14] evaluated performance of multicast protocols using parameters like throughput, Packet Delivery Ratio and Avg. End-to-End Delay. Results show that MAODV provides better characteristic when compared to the other protocols but having higher Avg. End-to-End Delay.

IV. SIMULATION

In this study, network simulation tool, NS2.34 [15] has been used as a simulation platform. NS2 is open source, object-oriented, discrete event-driven network simulation software which was developed in both languages including the Otcl and C++. It is excellent simulation software which can study network topology and analyze network transmission.

A. Network Performance Indicators

Following performance metrics are used to analyze the simulation results.

- **Packet Delivery Ratio (PDR):** This metric gives the ratio of the total data packets successfully received at the destination and total number of data packets generated at source. This number presents the effectiveness of a protocol.
- **Average End-to-End Delay (E2E Delay):** It is the calculation of typical time taken by packet (in average packets) to cover its journey from the source end to the destination end. In other words, it covers all of the potential delays such as route discovery, buffering processes, various in-between queuing stays, etc, during the entire trip of transmission of the packet.
- **Routing Overhead (RO):** The routing overhead describes how many routing packets for route discovery and route maintenance need to be sent in order to propagate the data packets. This metric discloses how efficient the routing protocol is.
- **Throughput:** It is defined as the total amount of data a receiver actually receives from the sender divided by the time between receiving the first packet and last packet. Throughput is the measure of how fast we can actually send packets through network.

Routing protocol is more privileged for lower value of E2E Delay and Routing Overhead metrics while higher value of PDR and throughput metric.

B. Network and Simulation Parameters

The experiments were carried out using the network simulator (ns-2). For all scenarios mobility of node is generated randomly with Random Way Point Mobility Model. NS-2 does not support to generate multicast traffic patterns so they are generated manually with the use of MAODV reference traffic files. Different multicast traffic files are generated with varying number of traffic connections, senders and receivers and then integrate with TCL script. As focus is to evaluate performance for multimedia applications both constant bit rate (CBR) data traffic as well as video traffic is generated. As NS-2.34 does not support Video traffic directly, a module called myEvalvid is integrate with it and used with TCL scripts. Evalvid [16] is a complete framework and toolset for evaluation of the quality of video transmitted over a real

or simulated communication network. It was integrated into NS 2.34 as shown in [17] and [18]. Also performance evaluation and enhancement of MPEG transmission over IEEE 802.11 WLAN is defined in [19].

MAODV and ODMRP are by default not available with NS-2.34. For performance evaluation of both protocol, first step is to integrate both protocol with NS 2.34. MAODV protocol is integrate with NS-2.34 as steps defined in [20]. ODMRP protocol is integrate with NS-2.34 from reference [21] and [22]. The randomly chosen source-destination pairs are spread in the network. Table I shows Simulation parameters which are used for creating TCL script. TCL scripts are then simulate with NS-2.34 for varying Node Density, No. of Senders, Multicast Group Size and Node Mobility. For each scenario, ten runs with different random seed were conducted and the results were averaged. The simulation outputs the trace files which are then analyzed using awk scripts. After extracting the various values from the trace file, the results were obtained.

Table I: Simulation Parameters

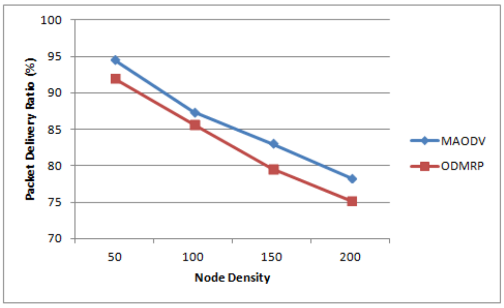
Parameter	Simulated Value
Channel Type	Wireless Channel
Antenna Model	Omni directional antenna
Radio Propagation Model	Two Ray Ground
Transmission Range	250 m
MAC Type	IEEE 802.11
Interface Queue Type	Priority Queue (50 Packets)
Routing Protocols	MAODV, ODMRP
Simulation Time	800 Second
Dimension	1000 X 1000 m
Movement Model	Generated with Setdest Utility
Traffic Type	CBR and Video files
No. of Nodes	50, 100, 150, 200
No. of Senders	10, 20, 30, 40
No. of Receivers	20, 40, 60, 80
Mobility of Nodes	5, 10, 15, 20, 25 m/s

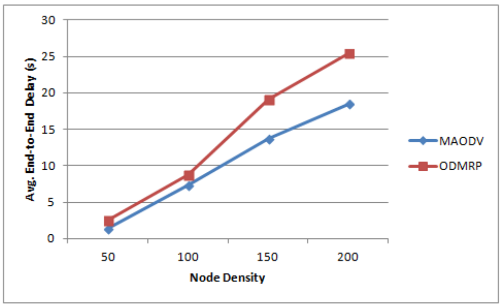
V. ANALYSIS OF SIMULATION RESULTS

The performance of the MAODV protocol is compared with ODMRP protocol in terms of Packet Delivery Ratio, Average End-to-End delay, Routing Overhead and Throughput. All experiment results presented in this section are average of ten simulation runs for all the four different parameters for performance metrics. The performance metrics measurements are with respect to node density, number of senders, multicast group size and node mobility.

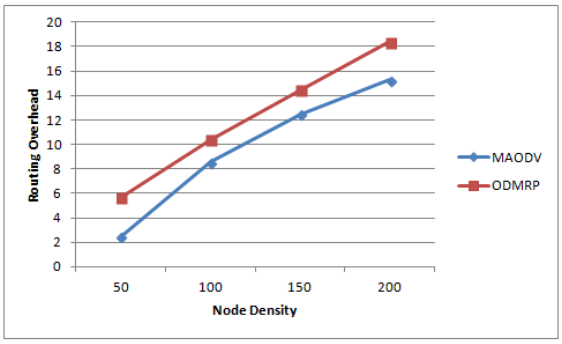
A. Node Density

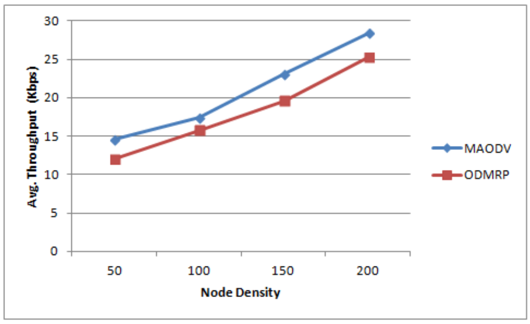
Figure 1 Shows the Simulation Results for Varying Node Density





(a) Packet Delivery Ratio **(b) Avg. End-to-End Delay**





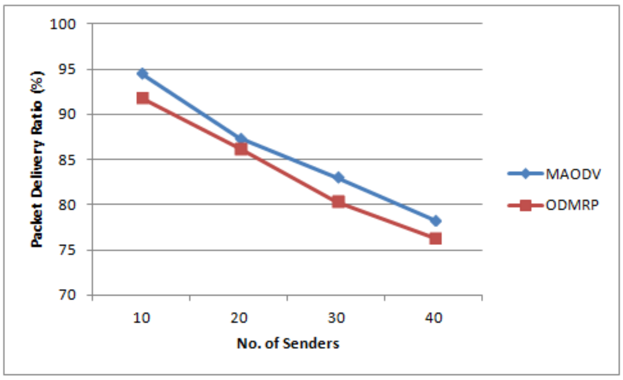
(c) Routing Overhead **(d) Throughput**

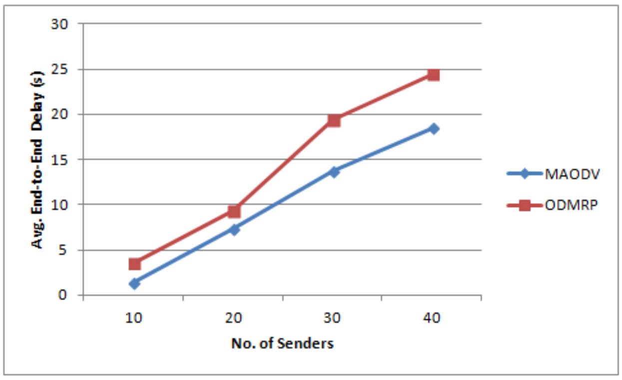
Figure 1: Performance Metrics for Node Density

By analyzing results with varying node density as shown in Figure1 performance of MAODV is better compared to ODMRP. It has 3.26 % higher Packet Delivery Ratio and 14.93 % higher throughput while 36.40 % lower Avg. End-to-End delay and 25.94 % lower Routing Overhead.

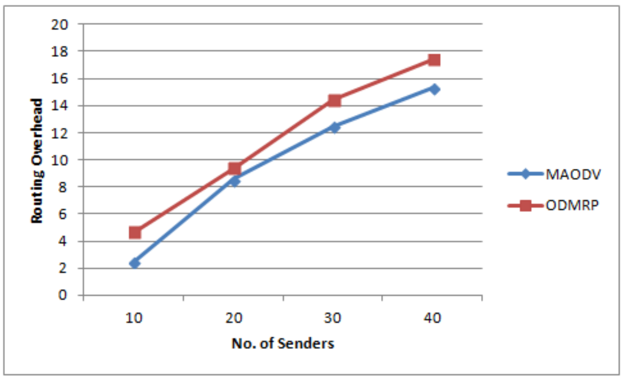
B. Number of Senders

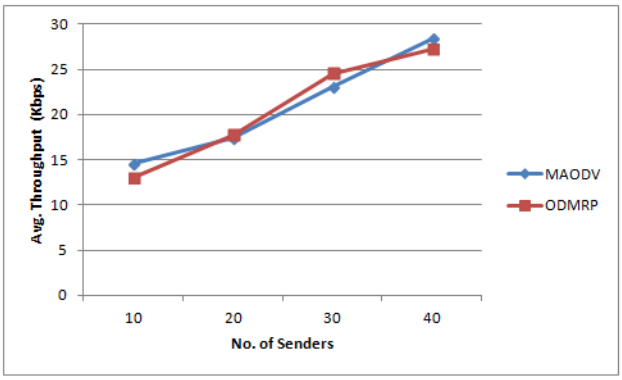
Figure 2 Shows the Simulation Results for Varying Number of Senders





(a) Packet Delivery Ratio **(b)Avg. End-to-End Delay**





(c)

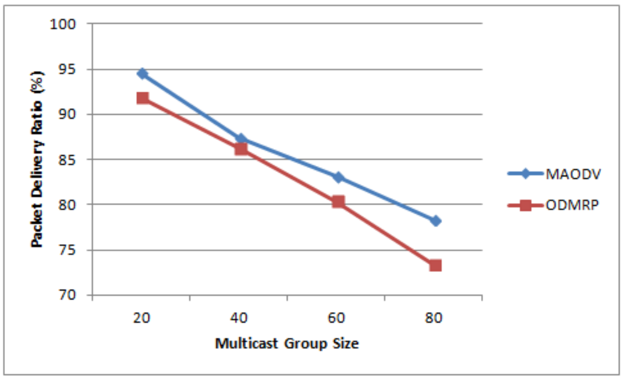
Routing Overhead **(d) Throughput**

Figure 2: Performance Metrics for Number of Senders

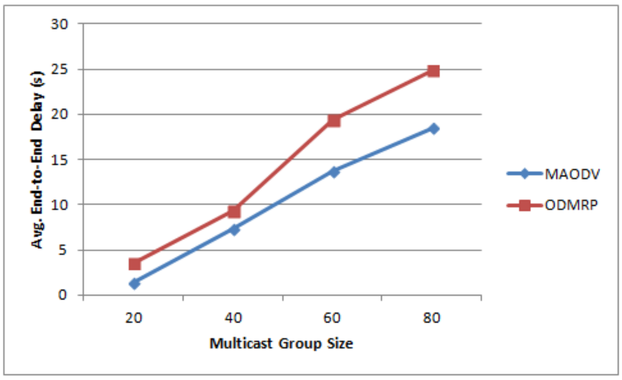
By analyzing results with number of senders as shown in Figure 2 performance of MAODV is better compared to ODMRP. It has 2.54% higher Packet Delivery Ratio and 1.02% higher throughput while 38.28% lower Avg. End-to-End delay and 18.20% lower Routing Overhead.

C. Multicast Group Size

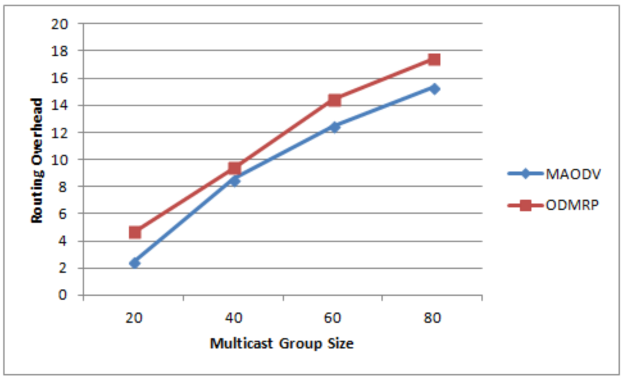
Figure 3: Shows the Simulation Results for Multicast Group Size



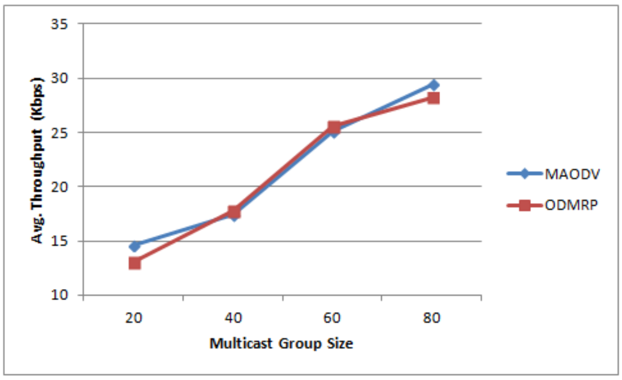
(a) Packet Delivery Ratio



(b)Avg. End-to-End Delay



(c) Routing Overhead



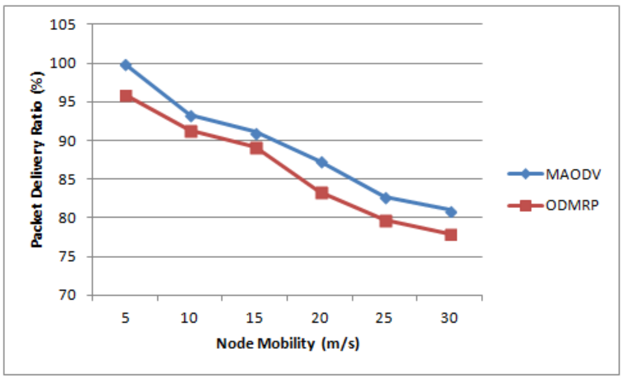
(d) Throughput

Figure 3: Performance Metrics for Multicast Group Size

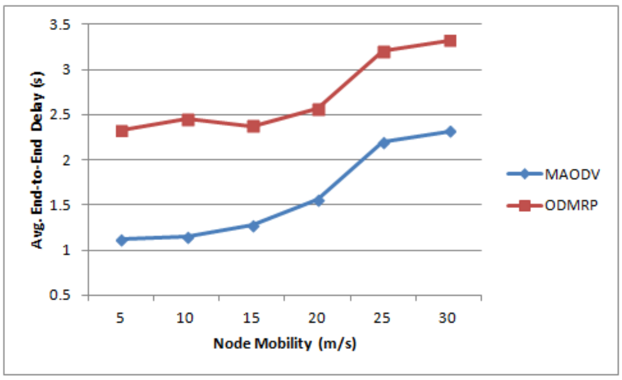
By analyzing results with multicast group size as shown in Figure 3performance of MAODV is better compared to ODMRP. It has 3.47% higher Packet Delivery Ratio and 2.17% higher throughput while 39.38% lower Avg. End-to-End delay and 18.20% lower Routing Overhead.

D. Node Mobility

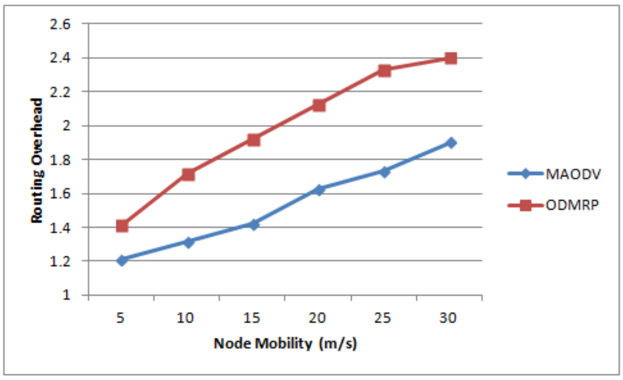
Figure 4 shows the Simulation Results for Varying Node Mobility

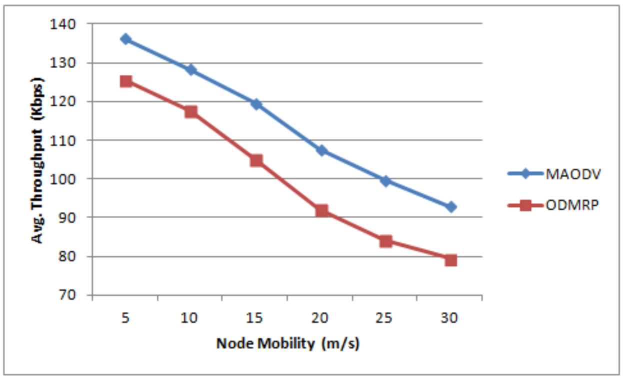


(a) Packet Delivery Ratio



(b) Avg. End-to-End Delay





(c) Routing Overhead **(d) Throughput**

Figure 4: Performance metrics for Node Mobility

By analyzing results with node mobility as shown in Figure 4 performance of MAODV is better compared to ODMRP. It has 3.48% higher Packet Delivery Ratio and 13.33% higher throughput while 68.54% lower Avg. End-to-End delay and 29.35% lower Routing Overhead.

VI. CONCLUSIONS

For MAODV and ODMRP protocol packet delivery ratio is decreases while avg. End-to-End delay and routing overhead are increases as increase in the number of senders, multicast group size, number of nodes and node mobility. Throughput is increases with increase in number of senders, multicast group size and nodes, while decreases with increases in node mobility. In all the cases MAODV performance is better with compared to ODMRP with multimedia traffic as combination of CBR data and Video. From section III, I found that ODMRP has higher PDR and higher Routing Overhead compared to MAODV for CBR data traffic. MAODV is more scalable than ODMRP with CBR data Traffic. The results shows that MAODV is suitable for multimedia applications in MANET.

MAODV protocol is maintains the single shared multicast tree. Thus, in any breaks in link that may occurs it does not have alternative paths between source and destination and requires longer times to repair the topology which in turn affect the longer delay delivering data to the receivers. Future task is to verify MAODV improvement for the same for CBR as well as multimedia traffic.

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